A biosystematic study of *Pelargonium* section *Ligularia*: 1. A new section *Subsucculentia*

J.J.A. van der Walt*, F. Albers[1], M. Gibby[2], D.E. Marschewski[1] and R.A. Price[3]

*Department of Botany, University of Stellenbosch, Stellenbosch, 7600 Republic of South Africa
[1]Institut für Botanik, Westfälische Wilhelms-Universität, D-48149 Münster, Germany
[2]Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.
[3]Department of Botany, The University of Georgia, Athens, Georgia 30602, U.S.A.

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The presumed relationship between *P. grandicalcaratum* Knuth, *P. karooicum* Compton & Barnes, *P. otaviense* Knuth and *P. spinosum* Willd., based on karyological characteristics, is confirmed by macromorphological, palynological, *rbc*L gene sequence studies and an analysis of phenolic compounds. These four species form the new section *Subsucculentia* J.J.A. v.d. Walt. Taxonomic treatments of the section and species are presented.

Die veronderstelde verwantskap tussen *P. grandicalcaratum* Knuth, *P. karooicum* Compton & Barnes, *P. otaviense* Knuth and *P. spinosum* Willd., gebaseer op kariologiese kenmerke, is bevestig deur makromorfologiese-, palinologiese-, *rbc*L geenvolgorde-studies en 'n analise van fenoliese verbindings. Hierdie vier spesies vorm die nuwe seksie *Subsucculentia* J.J.A. v.d. Walt. Taksonomiese uiteensettings van die seksie en spesies word aangebied.

Keywords: Biosystematics, Geraniaceae, new section *Subsucculentia*, *Pelargonium*.

*To whom correspondence should be addressed.

Introduction

In a reappraisal of *Pelargonium* section *Ligularia* (Sweet) Harv. (Albers *et al.* 1992), based on karyological data, it was suggested that the section is not monophyletic. Variation in chromosome number and size was used as a basis for subdividing the section into nine groups. It was proposed that some of these groups deserved recognition at sectional level, whereas others appeared to be more closely related to species from different sections of *Pelargonium*.

Four species, *P. grandicalcaratum* Knuth, *P. otaviense* Knuth, *P. karooicum* Compton & Barnes and *P. spinosum* Willd., were shown to have a basic chromosome number of $x = 10$ and large chromosomes and it was proposed that they should be placed in a new section. *P. otaviense* and *P. spinosum* were formerly classified in the section *Glaucophyllum* Harv., but van der Walt *et al.* (1990) showed that they should be excluded from that section.

The main aim of this multidisciplinary study was to determine whether macromorphological and palynological characteristics, the phenolic composition and *rbc*L gene sequences confirm the presumed relationship of the four species.

Material and Methods

Material

Origins of the plants investigated are given in Table 1.

Palynology

Living pollen grains were collected and treated according to the acetolysis method (Nilsson & Praglowski 1992). Observations were made with a Leitz Laborlux light microscope and a Joel scanning electron microscope (SEM), using secondary electron detection and an acceleration voltage of 5 kV. Material for observation in the SEM was first sputter coated with gold for 1.5 min at 20 μA. Twenty pollen grains were examined and the polar and equatorial measurements were made from pollen grains which were mounted in 50% glycerine. Descriptions are based on observations with both the light microscope and SEM.

Karyology

For the chromosome counts, root tips were treated with 0.002 mol 8-hydroxyquinoline for 4 h at 20°C and fixed in 3:1 absolute ethanol and glacial acetic acid. For meiosis, young flower buds were fixed in freshly prepared 6:3:1 absolute ethanol, chloroform and glacial acetic acid. The fixed material was stained in Snow's reagent (Snow 1963) and squashed in 45% acetic acid. Different chromosome sizes can be distinguished in the karyotypes of the section *Ligularia*. The chromosomes are classified into three classes based on size: 1, small 1.0–1.8 μm; 2, medium 1.7–2.3 μm; 3, large 2.0–3.0 μm. Measurements were made from camera lucida drawings.

Phenolic compounds

The phenolic compounds were detected with the aid of thin-layer chromatography (TLC). For the one-dimensional TLC, dried, frozen or fresh mature leaf material was extracted in acetone/H_2O. The sediment was extracted again in MeOH/H_2O. The pooled extracts were concentrated under reduced pressure and the resultant watery extract was defatted with petrolether by adding concentrated HCl (1:1). Hydrolysis was achieved by heating at 100°C for 15 or 40 min. The products of hydrolysis were extracted with ETOac. Flavones, flavonoles, anthocyanidines and hydroxybenzoic acids were identified by chromatographic comparison cellulose TLC sheets (Merck) against authentic samples (Roth), and with the aid of a spectral photometer (Marbry *et al.* 1970). Hydrolysable tannins were detected in the crude extracts by a specific colour reaction after Bate-Smith (1968). The products of hydrolysable tannins were separated and detected by TLC but not exactly determined. The solvent used was CAW (5:4) saturated with water. After treatment with 5% methanolic $AlCl_3$ the chromatograms were analyzed under UV light (366 nm).

*Rbc*L gene sequences

Total genomic DNA was isolated from fresh or silica gel-dried leaf tissue of *Pelargonium* species by grinding in liquid nitrogen, followed by extraction in hot CTAB buffer solution according to the method of Doyle & Doyle (1987). DNAs were further purified by caesium gradient centrifugation in most cases, or by further isopro-

Table 1 Origins of the specimens investigated

Species	Collector	Coll. No.	STEU No.	Locality
P. grandicalcaratum	Drijfhout	89/75	STEU 759	RSA, Cape, Studer's Pass
	Van der Walt	1185	STEU 1513	RSA, Cape, Garies
	Van der Walt	781	STEU 1515	RSA, Cape, Garies
	Van der Walt	942	STEU 2055	RSA, Cape, Botterkloof
	Hardy & Venter	s.n.	STEU 2157	Namibia, Schakalsberge
	Lavranos & Pehlemann	LAV 19018		Namibia, Macmillans Pass
P. karooicum	Drijfhout	1311	STEU 621	RSA, Cape, Vredendal
	Drijfhout	1373	STEU 622	RSA, Cape, Sannagas
	Van der Walt	758	STEU 1487	RSA, Cape, Bidouw Valley
	Van der Walt	1187	STEU 1524	RSA, Cape, Wallekraal
	Drijfhout	2724	STEU 2967	RSA, Cape, Wallekraal
P. otaviense	Lavranos	12881	STEU 943	Namibia, Namib Desert Park
	Gress	15135	STEU 2201	Namibia, Elandshoek
	Lavranos	16337	STEU 2202	Namibia, Omaruru River
	Albers	AL 2721		Namibia, S. Rössingberge
	Albers	AL 2722		Namibia, Mondlandschaft
P. spinosum	Drijfhout	1423	STEU 619	RSA, Cape, Richtersveld
	Moffett	1124	STEU 1357	RSA, Cape, Goodhouse
	Schonken	171	STEU 2087	RSA, Cape, Numies Mtns.
	Van der Walt	964	STEU 2097	RSA, Cape, Springbok
	Albers & Meve	AL&UM 87		Namibia, Rosh Pinah

panol precipitation. The *rbc*L gene was amplified from total DNA by the polymerase chain reaction (PCR) using an internal 5′ primer representing bases 4–26 of the gene, and an external 3′ primer designed from a highly conserved stem-loop region *ca.* 80–100 bases past the gene (Price & Palmer 1993). The PCR products were cleaned of primer by ultrafiltration with Centricon-100 filter units (Amicon Corp.) and the gene was sequenced directly from both strands using standard dideoxy chain-termination methods. Sequence data was compared by parsimony analysis using the programme package PAUP version (Swofford 1990).

Results

Macromorphology

All four species have recently been described and illustrated: *P. otaviense* and *P. spinosum* by van der Walt & Vorster (1981); *P. grandicalcaratum* (Figure 1) and *P. karooicum* by van der Walt & Vorster (1988). The reader is referred to these references for detailed descriptions and illustrations of the species.

The four species are sparsely to much-branched subshrubs or shrubs with subsucculent or somewhat woody stems. The leaves of *P. grandicalcaratum, P. otaviense* and *P. spinosum* are simple without deep incisions, whereas those of *P. karooicum* are palmately incised to palmately compound. The petioles of all four species are semi-persistent or persistent and in the case of *P. spinosum* they form hard spines. All four species have flowers with five petals and seven fertile stamens, except *P. karooicum* which has five fertile stamens. *P. grandicalcaratum* (Figure 1) and *P. otaviense* have the same peculiar floral morphology, in that their flowers are semi-closed and have a very prominent hypanthium. However, this may reflect similar adaptations to one type of pollinator, rather than indicate a common origin of the two species.

Palynology

The pollen grains of all four species can be described as more or less spherical, tricolporate, zonotreme monads. The size of the pollen grains varies from *ca.* 40 µm in *P. otaviense* to *ca.* 78 µm in *P. karooicum* (Table 2). The exine of all four species is *ca.* 5 µm thick (Table 2). The tectum of *P. grandicalcaratum* and *P. otaviense* (Figure 2) is considered to be foveolate, whereas that of *P. karooicum* and *P. spinosum* is striate-reticulate.

Karyology

Previous chromosome counts of *P. grandicalcaratum, P. otaviense, P. karooicum* and *P. spinosum* are confirmed (van der Walt *et al.* 1990; Albers *et al.* 1992). The four species have the same basic chromosome number, $x = 10$, a rather uncommon number in the genus (Table 2). *P. otaviense* and *P. spinosum* are diploids ($2n = 20$), but tetraploid and hexaploid counts have been made of *P. grandicalcaratum. P. karooicum* has the highest infraspecific polyploidy range ($2x$, $4x$, and $6x$). The infraspecific polyploidy levels show neither deviation in morphological features, nor geographical or edaphic preferences. The group is characterized by large chromosomes with very little size variation amongst the species.

Phenolic compounds (Table 3)

The flavonoid patterns of *P. grandicalcaratum* and *P. otaviense*

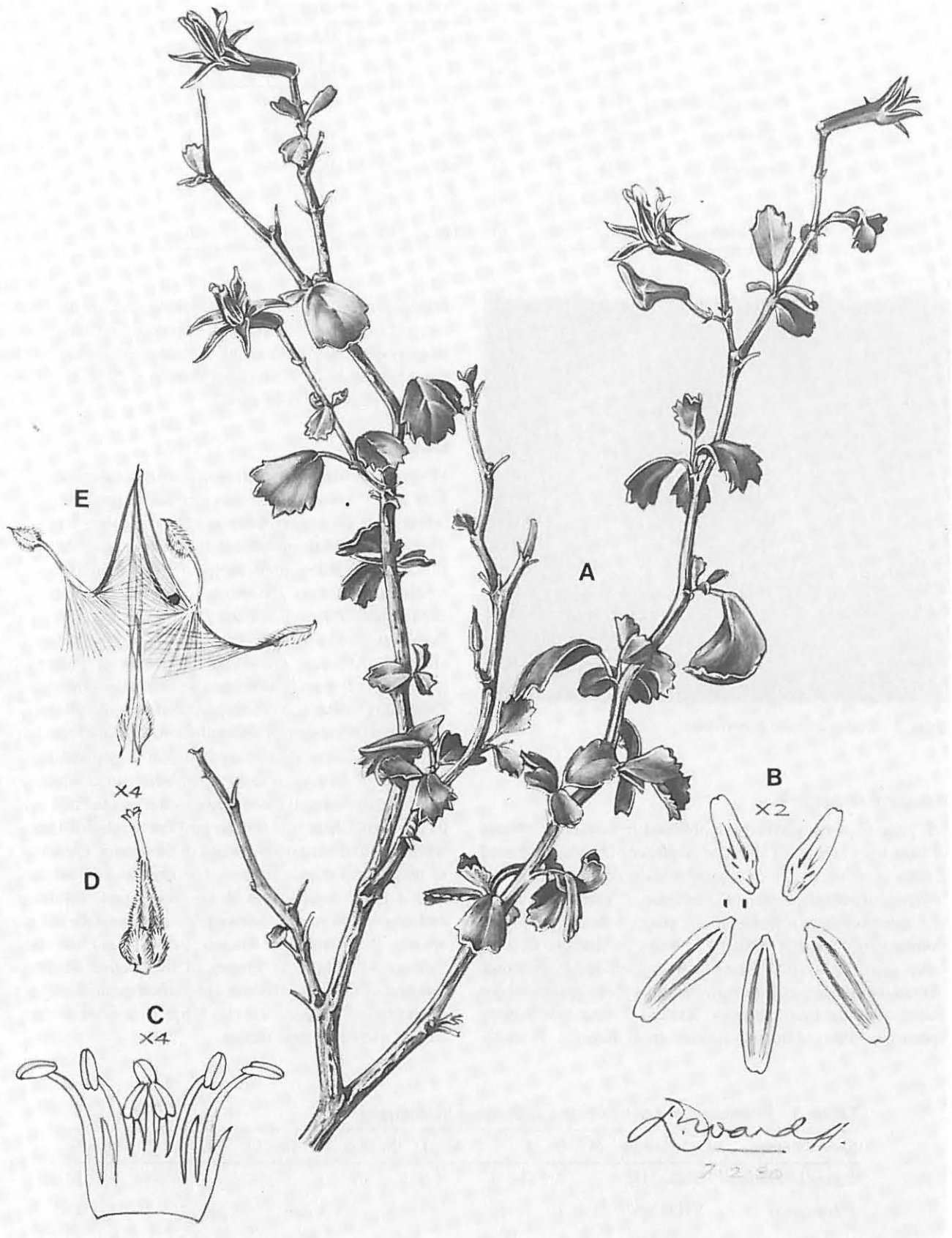

Figure 1 *P. grandicalcaratum*: A, flowering branch × 1; B, petals × 2; C, androecium × 4; D, gynoecium × 4; E, schizocarp with mericarp × 4.

are identical. The quantities of the detected hydrobenzoic acids and the hydrolysable tannins of all four species are very similar. The flavonoles of *P. grandicalcaratum, P. otaviense* and *P. spinosum* consist of quercetin and kaempherol but these substances are lacking in *P. karooicum*. The only known flavone present in the group is luteolin.

Table 2 Pollen grain dimensions of the specimens investigated

Taxon	STEU No.	Polar diameter (µm) Min	Max	$\bar{X}$	Equatorial diameter (µm) Min	Max	$\bar{X}$	Exine thickness (µm)
P. grandicalcaratum	1515	46	64	51	44	56	49	5
P. karooicum	621	66	110	79	64	89	77	5
P. otaviense	943	33	51	46	43	56	48	5
	2201	43	64	51	46	64	51	5
P. spinosum	s. n.	64	61	66	61	74	66	5

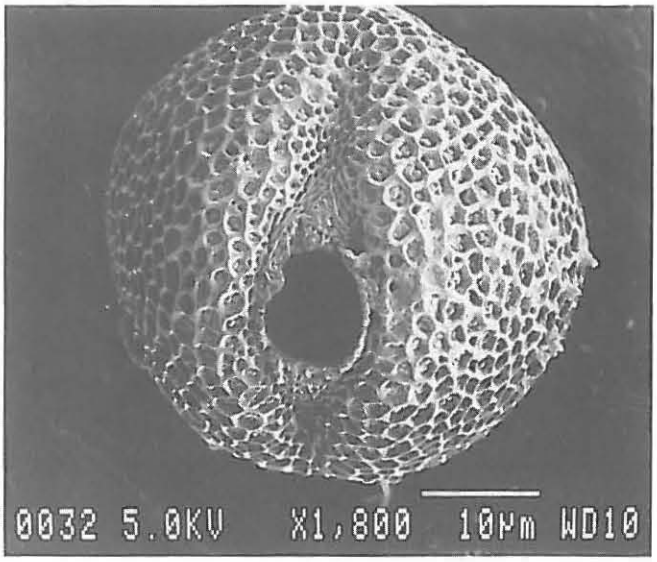

Figure 2 Pollen grain of *P. otaviense*.

*Rbc*L gene sequences

*Rbc*L gene sequences have been obtained from all four species and have been compared with the sequences from a number of the other sections, as part of a broader study of the genus (Price & Palmer, unpublished data). *P. otaviense, P. grandicalcaratum* and *P. spinosum* form a monophyletic group, with no base substitutions having been demonstrated between the first two of these species, and only two differences between them and *P. spinosum*. *P. karooicum* groups closely with the other three species of the section, differing from them by 3,3 and 5 base substitutions respectively. Two additional species from Eurasia, *P. endlicherianum* Fenzl and *P. quercetorum* Agnew, are also very similar to *P. karooicum* in their *rbc*L sequences, differing by 2 and 4 bases respectively. Both of the Eurasian species have a chromosome number of $2n = 34$, rather than $2n = 20$ as in the four species studied (Gibby *et al.* 1990).

Discussion

Morphologically, *P. grandicalcaratum, P. karooicum, P. otaviense* and *P. spinosum* are very similar, although the habit and leaves of *P. karooicum* differ in certain respects from the other three. *P. grandicalcaratum* and *P. otaviense* have the same floral structure and pollen grain morphology, indicating a very close relationship between the two species (van der Walt & Vorster 1981, 1988). *P. karooicum* and *P. spinosum* have the same basic floral structure and the tectum sculpture of their pollen grains is identical. Although more than one level of polyploidy was reported for *P. grandicalcaratum* and *P. karooicum* (Albers *et al.* 1992), this variation was not associated with morphological variation, or with geographical distribution, or edaphic preference.

The very similar flavonoid patterns of *P. grandicalcaratum, P. otaviense, P. karooicum* and *P. spinosum* (two of which are identical) and the unusual basic chromosome number of $x = 10$, leave no doubt that these four species are closely related. They differ to such an extent from other species in the section *Ligularia s. l.* as to warrant a separate section. The new section *Subsucculentia* J.J.A.v.d.Walt is described in the second part of this article. *P. endlicherianum* and *P. quercetorum* are possibly allotetraploid species that share one nuclear genome and the chloroplast genome with the four species of the section *Subsucculentia*. Because of their difference in chromosome number and possible allopolyploid ancestry, the two Eurasian species are not treated here as part of the new section.

Table 3 Phenolic compounds of the specimens investigated

Species studied	Collection no.	M	Q	K	L	A	I	Qm	Km	Ch	De	Cy	Pe	Ga	Pr	HT	CG
P. grandicalcaratum	STEU 1515	-	3	2	1	-	-	-	-	-	-	-	-	3	3	2	2
P. karooicum	STEU 2967	-	3	-	?	-	-	-	-	-	-	-	-	2	2	2	2
	STEU 621	-	3	-	?	-	-	-	-	-	-	-	-	2	2	2	2
P. otaviense	STEU 2201	-	3	2	1	-	-	-	-	-	-	-	-	3	3	2	2
P. spinosum	STEU 2087	-	3	2	3	-	-	-	-	-	-	-	-	3	3	1	2

M, myricetin; Q, quercetin; K, kaempferol; L, luteolin; A, apigenin; I, isorhanmetin, Qm, quercetin-3-methylether, Km, kaempferol-4-methylether; Ch, chrysoeriol; De, prodelphinidin; Cy, procyanidin; Pe, propelargonidin; Ga, gallic acid; Pr, protocatechuic acid (the two latter are hydroxybenzoic acids); HT, hydrolysable tannins; CG, C-glycosyl-flavone
1, Low content; 2, medium content; 3, main compound; ? questionable

Taxonomic treatment of the section

Pelargonium* section *Subsucculentia *J.J.A.v.d.Walt* sect. nov.

Type species: *P. spinosum* Willd.

Diagnostic features

Frutices vel suffrutices sparsim vel crebro ramosi, decidui, plerumque olentes. Caules subsucculenti vel suffruticosi aliquantum. Folia vilgo simplicia subsucculentaque; lamina nonnunquam palmatim incisa vel etiam compositae; petiolus plusminusve persistens velut spina. Pseudo-umbellae 1–10 florae. Pedicellus nonnunquam hypanthium aequans plerumque autem brevior eo. Hypanthium bene evolutum, saepe maxime cospicuum. Petala 5, alba, flava vel subrosea, quorum postica antiquaque plusminusve aequo amplitudine. Stamina fertilia 5 vel 7.

Sparsely to much-branched, deciduous, usually aromatic subshrubs or shrubs. Stems subsucculent to somewhat woody. Leaves usually simple and subsucculent; lamina sometimes palmately incised or even compound; petiole semi-persistent or persistent to form spines. Pseudo-umbels 1–10-flowered. Pedicel sometimes as long as but usually shorter than hypanthium. Hypanthium well developed and often very conspicuous. Petals 5, white, yellow or pinkish; posterior and anterior petals more or less the same size. Fertile stamens 5 or 7.

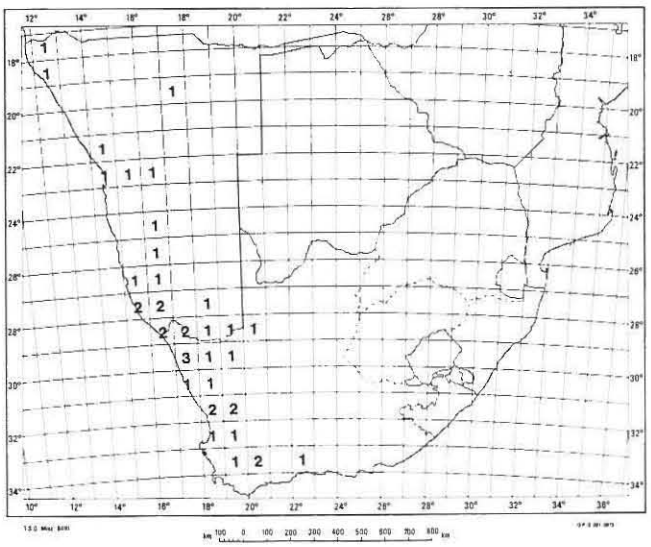

Figure 3 Distribution and concentration of species of the section *Subsucculentia*.

Geographical distribution (Figure 3)

The section *Subsucculentia* has a long distribution range in a north–south direction on the western side of southern Africa. Its distribution area stretches from the north-western part of Namibia southwards along the west coast to the Western Cape. Only one species, *P. otaviense*, occurs north of 27°S latitude and is widely distributed in Namibia.

Key to species

1a. Leaves palmately incised to compound with linear segments/pinnae, stems decumbent, fertile stamens 5 ..... ***P. karooicum***

1b. Leaves simple without deep incisions, stems erect, fertile stamens 7 ..... **2**

2a. Petioles persistent forming hard spines, leaves dimorphous, flowers open wide ..... ***P. spinosum***

2b. Petioles semi-persistent but not forming hard spines, leaves not dimorphous, flowers partially closed **3**

3a. Leaves subsucculent, lamina obovate, petioles much shorter than laminae ..... ***P. grandicalcaratum***

3b. Leaves membranous, lamina reniform to cordiform, petioles as long as or longer than laminae ***P. otaviense***

Taxonomic treatment of the species

1. *Pelargonium spinosum* *Willd.*, Species Plantarum 3: 681 (1800); Pers.: 233 (1806); Ait.f.: 179 (1812); DC.: 661 (1824); Drége: 209 (1843); Harv.: 298 (1860); Knuth: 437 (1912); Dinter: 376 (1920); Merxmüller & Shreiber: 9, 12 (1966); Schonken: 49 (1980); Van der Walt & Vorster: 133 (1981). Iconotype: Paterson t. 13 (1789).

Geranium pungens Poir.: 759 (1812).

Diagnostic features

Much-branched, spiny aromatic subshrub. Stems subsucculent, erect, bark of older stems peeling off in paper-like strips. Leaves simple, subsucculent, glabrous but with glandular hairs, dimorphous; large leaves unifoliolate, lamina reniform, margin dentate, petiole much longer than lamina, persistent to form hard spines when lamina is shed; small leaves simple, petiole short and deciduous; stipules persistent to form thorns. Pseudo-umbels 3–10-flowered. Pedicel as long as or longer than hypanthium. Petals 5, white to light pink, posterior two with purple feather-like markings and slightly larger than anterior three. Fertile stamens 7.

Geographical distribution (Figure 4)

P. spinosum occurs in the southern part of Namibia and in the Northern Cape. It is especially common along the Orange River and its distribution range stretches from the west coast eastward to near Upington. The annual rainfall is less than 200 mm and usually occurs during winter. *P. spinosum* is found mostly along mountain slopes on rocky and sandy soil, between boulders.

Selected specimens studied

—**2615** (Luderitz): Haalenberg (–DA), *Wendt s.n.* (WIND).
—**2616** (Aus): 10 km NW of Aus (–CA), *Drijfhout 2078* (STEU).
—**2715** (Bogenfels): Klinghardt Mountains (–BC), *Dinter 3913* (BOL, PRE, SAM, Z).
—**2716** (Witputz): Farm Tierkloof (–BD), *Giess 14422* (PRE, WIND); Farm Namuskluft (–DD), *Giess 13631* (WIND).

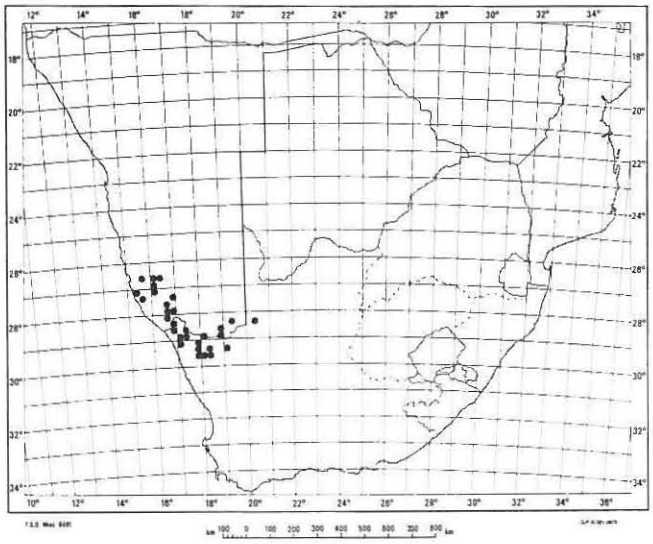

Figure 4 Geographical distribution of *P. spinosum*.

—**2816** (Oranjemund): Obib Mountains (–BA), *Merxmüller & Giess 28629* (PRE, WIND); Helskloof (–BD), *Van Jaarsveld 2532* (PRE).
—**2817** (Vioolsdrif): Perdewater (–CC), *Drijfhout 1509* (STEU).
—**2818** (Warmbad): Farm Eendoorn (–DB), *Giess & Müller 12146* (WIND).
—**2819** (Ariamsvlei): Rooikop (–AD), *Merxmüller & Giess 3307* (PRE, WIND).
—**2820** (Kakamas): Riemvasmaak (–AD), *Barnard s. n.* (SAM).
—**2917** (Springbok): Steinkopf (–BD), *Herre 12179* (STE); Hester Malan Nature Reserve (–DB), *Van der Walt 964* (STEU).
—**2918** (Gamoep): Naib (–AD), *Acocks 19445* (PRE, SRGH).
—**2919** (Pofadder): 18 km W. of Aggenys (–AC), *Wisura 3637* (NBG, PRE); W. of Ratelkraal (–CA), *Barker 134* (NBG).

2. *P. otaviense* *Knuth* in Das Pflanzenreich 4, 129: 439 (1912); Dinter: 376 (1920); Giess: 27 (1959); Merxmüller & Schreiber: 9, 12 (1966); Nordenstam: 20 (1974); Van der Walt & Vorster 105 (1981). Type: Namibia: – 'Otavi, auf dem Kamme der bewalten Otavi-Berge', *Dinter 937* (SAM!).

P. roessingense Dinter: 47 (1914); Dinter: 376 (1920). Topotype: Namibia: – 'Diabas Hügel bei Roessing', *Dinter 8463* (K!).

P. damarense Knuth: 312 (1915). Type: Namibia – 'Namib, Kieswüste bei Rössing, *Engler 6070* (B⁺).

Diagnostic features

Sparsely branched, aromatic shrub. Stems rather woody, erect, bark peeling off in paper-like strips. Leaves simple, membranous, pubescent; lamina reniform to cordiform, shallowly 3–5-lobed, margin coarsely dentate; petiole as long as or longer than lamina, persistent but not spinescent; stipules persistent but not spinescent. Pseudo-umbels 2–6-flowered. Pedicel shorter and much thinner than hypanthium. Petals 5, almost equal in size and shape, straight and almost parallel so that flower remains partially closed, white, light greenish, pinkish or purplish with fine reddish lines. Fertile stamens 7.

Geographical distribution (Figure 5)

P. otaviense is widely distributed in Namibia from the Kunene River in the north, to near the Orange River in the south. It extends from near the Atlantic Ocean eastwards to the Otavi Mountains. The entire area lies in the summer-rainfall region with an annual precipitation of 200–600 mm. *P. otaviense* has been recorded on soils derived from granite, quartzite, dolomite and marble.

Selected specimens studied

—**1712** (Posto Velho): Otjihipa Mountains (–BC), *Vahrmeijer 2560* (PRE).
—**1812** (Sanitatas): 12.5 km N. of Sarusas (–CD), *Giess & Leippert 7464* (WIND).
—**1917** (Tsumeb): Otavi Mountains (–CB), *Dinter 937* (SAM).
—**2114** (Uis): E. of Königstein (–BA), *Nordenstam 2814* (WIND).
—**2214** (Swakopmund): Rossing Mountains (–DB), *Giess 1731* (PRE, WIND).
—**2215** (Trekkopje): Welwitschia flats (–AC), *Giess 3084* (PRE, WIND).
—**2216** (Otjimbingwe): Farm Kaan Dam (–CC), *Giess 13527* (MO, PRE, WIND).
—**2416** (Maltahohe): Bullspoort (–AB), *Strey sub SUG 101* (BOL).
—**2718** (Grünau): Between Kraaikloof and Waterfall, Karasberg (–BC), *Pearson 7895* (BOL, PRE, SAM).

3. *Pelargonium grandicalcaratum* *Knuth* in Repertorium novarum specierum regni vegetabilis 15: 135 (1918); Van der Walt & Vorster: 61 (1988). Type: Namibia – 'Geröll am Abhang des Dreikugel-Berges im Klinghardt-Gebirge', *Schäfer 579* (B⁺, holo.); 'Klinghardtgebirge', *Dinter 3990* (BOL, neo.!, PRE!; Z!).

P. squarrosum Dinter: 343 (1920).

Diagnostic features

Much branched, aromatic shrub. Stems somewhat woody, erect, smooth or with margin longitudinal grooves. Leaves simple, subsucculent, pubescent; lamina obovate, entire but distal part coarsely dentate; petiole much shorter than lamina, semi-persistent; stipules membranous, caducous. Pseudo-umbels 1–5-flowered. Pedicel shorter and much thinner than hypanthium. Petals 5, straight and almost parallel so that flower remains partially closed, whitish or pale yellow and tinted wine-red, posterior two with feather-like wine-red markings and smaller than anterior three. Fertile stamens 7.

Geographical distribution (Figure 6)

P. grandicalcaratum occurs in the south-western part of Namibia and in a strip parallel to the west coast of the Cape Province. It is

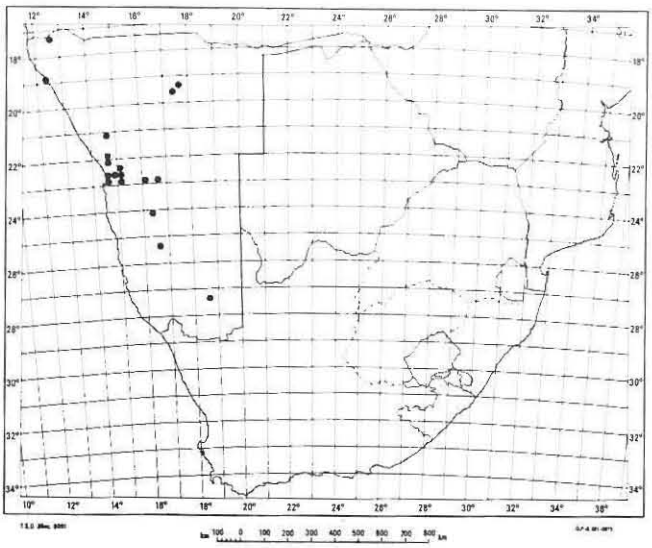

Figure 5 Geographical distribution of *P. otaviense*.

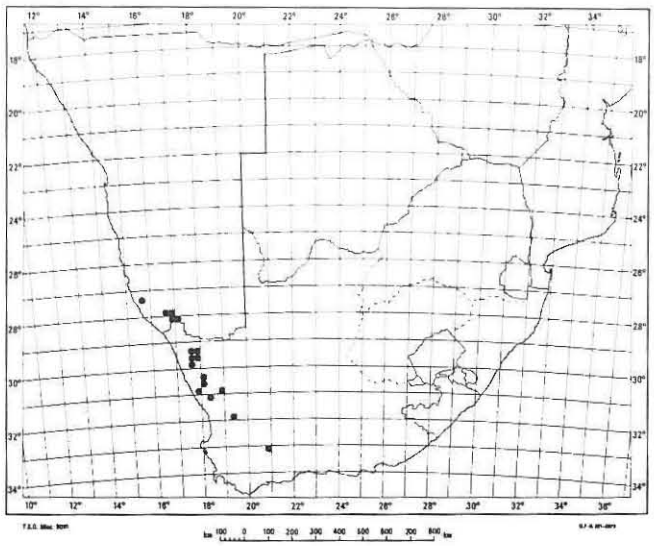

Figure 6 Geographical distribution of *P. grandicalcaratum*.

also known from a single more inland locality in the district of Montagu. The entire distribution area receives an annual rainfall of less than 200 mm during the winter months. *P. grandicalcaratum* usually grows on sandy soil amongst rocks of granite or sandstone.

Selected specimens studied

—**2715** (Bogenfels): Klinghardt Mountains (–BC), *Merxmüller & Giess 28391* (PRE, WIND).

—**2716** (Witputz): Farm Spitskop near Rosh Pinah (–DC), *Merxmüller & Giess 14397* (PRE, WIND); Farm Namaskluft (–DD), *Merxmüller & Giess 14343* (PRE, WIND).

—**2816** (Oranjemund): Kahanstal, Lorelei Copper Mine (–BB), *Dinter 8170* (BOL, S, Z).

—**2817** (Vioolsdrif): Hunsberg (–AA), *Hardy 2642* (PRE).

—**2917** (Springbok): E. of Steinkopf (–BD), *Coetzee 6* (STEU); Between O'Kiep and Nababeep (–DB), *Coetzee 5* (STEU); Wildepaardehoek Pass (–DC), *Drijfhout 2738* (STEU).

—**3017** (Hondeklipbaai): Between Sandkopdrif and Garies (–DD), *Van der Walt 781* (PRE, STEU).

—**3018** (Kamiesberg): Studer's Pass (–AC), *Schonken 163* (STEU); Kamiesberg Pass (–AC), *Van der Walt 560* (PRE, STEU); Near Garies (–CA), *Van der Walt 554* (PRE, STEU).

—**3118** (Vanrhynsdorp): Near Bitterfontein (–AB), *Coetzee 2* (STEU); Botterkloof Pass (–CD), *Drijfhout 1522* (STEU).

—**3320** (Montague): Near Constable (–BB), *Acocks 19116* (PRE).

4. *Pelargonium karooicum* *Compton* in Transactions of the Royal Society South Africa 19: 295 (1931). Type: Cape Province, Whitehill, *Compton 2964* (BOL, holo.!).

Diagnostic features

Tuft-shaped subshrub, branched mostly at base. Stems subsucculent, decumbent, smooth. Leaves palmately incised but usually palmately compound, subsucculent, puberulous; lamina broadly ovate, pinnae/segments linear and semi-terete; petiole relatively short (2–5 mm), semi-persistent; stipules membranous, not persistent. Pseudo-umbels 1–2-flowered. Pedicel much shorter than hypanthium. Petals 5, white, pale yellow or pink, posterior two with wine-red feather-like markings and slightly larger than anterior three. Fertile stamens 5 .

Geographical distribution (Figure 7)

P. karooicum occurs in the Western Cape Province. Its distribution range stretches from the vicinity of Kleinsee in the northwest, to near Oudtshoorn in the east. Most of this area receives an annual rainfall of between 100 and 200 mm, but some parts may get as much as 400 mm. This area falls in the winter-rainfall region, although the eastern part also receives some rain during summer. *P. karooicum* is mostly found on rocky and sandy soil but has also been recorded from sandveld.

Selected specimens studied

—**2917** (Springbok): Farm Rooivlei near Kleinsee (–CA), *Drijfhout 2873* (STEU); Wildepaardehoek Pass (–DC), *Drijfhout 2746* (STEU).

—**3118** (Vanrhynsdorp): Between Nuwerus and Vanrhynsdorp (–BC), *Van der Walt 945* (STEU); Near Olifants River mouth (–CA), *Drijfhout 1311* (STEU); Farm Liebendal (–CB), *Hall 3930* (NBG); Between Vredendal and Lutzville (–CB), *Van der Walt 765* (STEU); Near Koekenaap (–CB), *Van der Walt 771* (STEU).

—**3119** (Calvinia): 49 km from Loeriesfontein on road to Calvinia (–BC), *Moffett 1220* (STEU).

—**3218** (Clanwilliam): SE of Nuwerus (–DC), *Pearson 6892* (BOL).

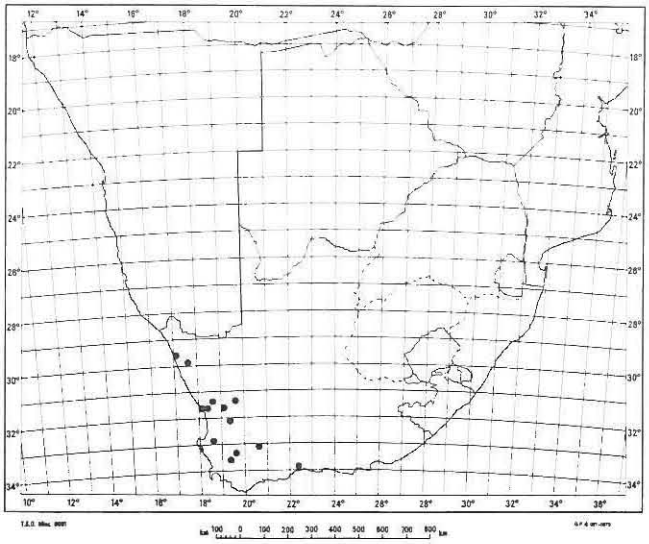

Figure 7 Geographical distribution of *P. karooicum.*

—**3219** (Wuppertal): Biedouw Valley (–AB), *Van der Walt 758* (STEU).

—**3319** (Worcester): Karoo National Botanical Garden (–CB), *Van der Walt 530* (STEU); *Winkler 37* (BOL).

—**3320** (Montague): Karoo Garden Whitehill (–BA), *Compton 2964* (BOL).

—**3322** (Oudtshoorn): Klipdrif (–CD), *Schlechter 2282* (Z).

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